Audiometric apparatus and associated screening method

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Inventor:

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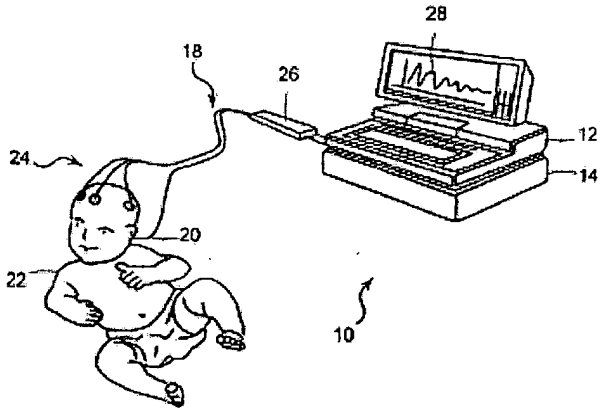
Abstract of corresponding document: **US5601091**

An audiometric screening apparatus and associated method provides fast, low-cost, noninvasive screening of a subject's heating. The apparatus includes a signal processor for generating a stimulus signal and a probe electrically coupled to the signal processor and insertible in a subject's ear. The probe includes a transmitter to transmit the stimulus signal into the ear and a receiver for receiving a first response signal from the subject's ear. An electrode, electrically coupled to the signal processor, is attached to the subject's scalp for sensing a second response signal. The signal processor processes the first response signal to provide an evoked otoacoustic emission signal and processes the second response signal to provide an auditory evoked potential signal.



Audiometric apparatus and associated screening method

Claims of corresponding document: **US5601091**

I claim:

1. An audiometric apparatus comprising:
a signal processor for generating a first stimulus signal;
a probe electrically coupled to the signal processor and insertible in a subject's ear, the probe including (i) a transmitter for transmitting the first stimulus signal into the subject's ear and (ii) a receiver for receiving a first response signal from the subject's ear;
an electrode, electrically coupled to the signal processor and attachable to the subject's scalp, for sensing a second response signal from the subject's scalp; and
the signal processor processing the first response signal to provide an evoked otoacoustic emission signal and processing the second response signal to provide an auditory evoked potential signal.

2. The apparatus of claim 1 wherein the first stimulus signal comprises an amplitude modulated signal.

3. The apparatus of claim 1 wherein the first stimulus signal comprises at least one paired tonal stimuli.

4. The apparatus of claim 1 wherein the signal processor processes the first and second response signals in parallel.

5. The apparatus of claim 4 wherein the signal processor processes the first and second response signals simultaneously.

6. The apparatus of claim 1 wherein the signal processor generates a second stimulus signal, the transmitter transmits the second stimulus signal into the subject's ear, the receiver receives a third response signal from the subject's ear, and the signal processor processes the third response signal to provide an acoustic reflectivity signal.

7. The apparatus of claim 1 further comprising a plurality of electrodes, electrically coupled to the signal processor and connectable to the subject's scalp, for sensing a second response signal from the subject's scalp.

8. The apparatus of claim 1 further comprising:
a digital signal processing element;
a memory electrically coupled to the digital signal processing element;
a digital-to-analog converter electrically coupled to the digital signal processing element for converting the first stimulus signal from a digital format into an analog format;
an attenuator electrically coupled to the digital-to-analog converter for regulating the first stimulus signal;
a filter electrically coupled to the receiver and the electrode for filtering the first and second response signals;
an analog-to-digital converter electrically coupled to the filter for converting the first and second response signals from an analog format into a digital format for the digital signal processing element.

9. The apparatus of claim 8 further comprising:
a first amplifier electrically coupled to the probe for providing amplified first response signals to the filter; and
a second amplifier electrically coupled to the electrode for providing amplified second response signals to the filter.

10. The apparatus of claim 1 further comprising:
a control processor for requesting an evoked otoacoustic emission signal and an auditory evoked potential signal;
a display electrically coupled to the control processor for displaying one or more characteristics of the evoked otoacoustic emission signal and the auditory evoked potential signal; and
an input device electrically coupled to the control processor to enable a user to request the evoked otoacoustic emission signal and the auditory evoked potential signal.

11. An auditory screening method comprising:
attaching an electrode to a subject's scalp;
inserting a probe, including a transmitter and a receiver, in a subject's ear;
transmitting a first stimulus signal from the transmitter into the subject's ear;
receiving a first response signal from the subject's ear via the receiver;
sensing a second response signal from the subject's scalp via the electrode; and
processing the first response signal to provide an evoked otoacoustic emission signal and the second response signal to provide an auditory evoked potential signal.

12. The method of claim 11 wherein the first stimulus signal comprises an amplitude modulated signal.

13. The method of claim 11 wherein the first stimulus signal comprises at least one paired tonal stimuli.

14. The method of claim 11 further comprising processing the first and second response signals in parallel.

15. The method of claim 11 further comprising processing the first and second response signals simultaneously.

16. The method of claim 11 further comprising displaying one or more characteristics of the evoked otoacoustic emission signal and the auditory evoked potential signal.

17. The method of claim 9 further comprising:
generating a second stimulus signal;
transmitting the second stimulus signal into the subject's ear;
receiving a third response signal from the subject's ear; and
processing the third response signal to provide an acoustic reflectivity signal.

18. An auditory screening method comprising:
attaching an electrode to a subject's scalp;
inserting a probe in a subject's ear;
generating a first stimulus signal comprising a plurality of paired tonal stimuli;
transmitting the first stimulus signal from the probe into the subject's ear;
receiving a first response signal from the subject's ear via the probe;
sensing a second response signal from the subject's scalp via the electrode; and
processing the first response signal to provide an evoked otoacoustic emission signal and processing the second response signal to provide an auditory evoked potential signal.

19. The method of claim 18 further comprising processing the first and second response signals in parallel.

20. The method of claim 14 further comprising:
generating a second stimulus signal;
transmitting the second stimulus signal into the subject's ear;
receiving a third response signal from the subject's ear; and
processing the third response signal to provide an acoustic reflectivity signal.

21. An auditory screening method comprising:
attaching an electrode to a subject's scalp;
inserting a probe in a subject's ear;
transmitting a stimulus signal into the subject's ear;
receiving a response signal from the subject's ear via the probe; and
averaging the response signal over a plurality of intervals to produce a plurality of subaverages;
inversely weighting each subaverage; and
combining the inversely weighted subaverages to produce an auditory indication signal.

22. The method of claim 21 wherein the auditory indication signal is an evoked otoacoustic emission signal and or an auditory evoked potential signal.

23. The method of claim 21 wherein the first stimulus signal comprises an amplitude modulated signal.

24. The method of claim 21 further comprising inversely weighting each subaverage based the variance and content of the response signal.

25. The method of claim 21 wherein the combining step comprises averaging the inversely weighted subaverages to produce an auditory indication signal.

26. The method of claim 25 wherein the combining step comprises:
performing a Fourier transform for each subaverage;
determining real and imaginary components of the Fourier transform at specified frequencies;
independently estimating variance of each component; and
determining the probability of an auditory indication signal using an F statistic.

27. An audiometric apparatus comprising:
a hand-held housing;
a signal processor, disposed in the housing, for generating a first and second stimulus signals;
a probe extending from the housing and insertible in a subject's ear, the probe including (i) a transmitter for transmitting the first and second stimulus signals into the subject's ear and (ii) a receiver for receiving first and second response signals from the subject's ear; and
the signal processor processing the first response signal to provide an evoked otoacoustic emission signal and processing the second response signal to provide an auditory indication signal.

28. The apparatus of claim 27 wherein the auditory indication signal is a tympanometry signal or an acoustic reflectivity signal.

29. The apparatus of claim 27 wherein the first stimulus signal comprises an amplitude modulated signal.

30. The apparatus of claim 27 wherein first stimulus signal comprises at least one paired tonal stimuli.

31. The apparatus of claim 27 wherein the signal processor processes the first and second response signals in parallel.

32. The apparatus of claim 27 further comprising:
a digital signal processing element;
a memory electrically coupled to the digital signal processing element;
a digital-to-analog converter electrically coupled to the digital signal processing element for converting the first stimulus signal from a digital format into an analog format;
an attenuator electrically coupled to the digital-to-analog converter for regulating the first stimulus signal;
an amplifier electrically coupled to the receiver for providing amplified first response signals;
a filter electrically coupled to the amplifier for filtering the first and second response signals;
an analog-to-digital converter electrically coupled to the filter for converting the first and second response signals from an analog format into a digital format for the digital signal processing element.

33. The apparatus of claim 27 further comprising:
a control processor for requesting an evoked otoacoustic emission signal and an auditory evoked potential signal;
a display electrically coupled to the control processor for displaying one or more characteristics of the evoked otoacoustic emission signal and the auditory evoked potential signal; and
an input device electrically coupled to the control processor to enable a user to request the evoked otoacoustic emission signal and the auditory evoked potential signal.

34. The apparatus of claim 27 further comprising a docking station for receiving the housing, the docking station including a battery charger for recharging the signal processor and a printer for printing one or more characteristics of evoked otoacoustic emission signal and the auditory evoked potential signal.

35. An auditory screening method comprising:
inserting a probe, including a transmitter and receiver, in a subject's ear;
transmitting first and second stimulus signals from the transmitter into the subject's ear;
receiving first and second response signals from the subject's ear via the receiver; and
processing the first response signal to provide an evoked otoacoustic emission signal and processing the second response signal to provide an auditory indication signal.

36. The method of claim 35 wherein the auditory indication signal is a tympanometry signal or an acoustic reflectivity signal.

37. The method of claim 35 further comprising displaying the evoked otoacoustic emission signal and the

auditory evoked potential signal.
